FOUNDATION ANALYSIS

DENVER COLORADO

FOUNDATION ANALYSIS
DENVER, COLORADO

1. Scope

The results of the foundation investigation and analysis for the Denver Colorado are presented in this report. The scope of the study was to (1) evaluate the engineering properties of the subsoils; (2) provide allowable soil bearing pressures and (3) recommend types and depths of foundation elements and other measures pertinent to foundation design and construction.

2. Proposed Construction

This project involves the construction of an approximately 84 Military Family Housing units

3. Subsurface Investigations

3.1. General

The field Investigation for the Housing Area was conducted on 23-24 August 2000 The exploratory program consisted of five (5) test borings numbered sequentially from FS00-l through FS00-5. The borings were advanced with a Gus Pech 1300 truck mounted soil sampling rig using 10.8 cm (4.25-inch) inside diameter (I.D.) hollow stem augers. All borings were drilled to a depth of 6.1 meters (20 feet).

Borings were located and staked in the field. Borings were located by measuring (steel tape) distances from existing structures. Base personnel provided utility clearances.

TABLE 1: Summary of Borings

Boring Number	Date Drilled	Total Depth		Water During Drilling	Water After Drilling
		M	(ft)		
FS00—l	23 Aug 2000	6.1	(20)	Not Encountered	Not Encountered
FS00—2	23 Aug 2000	6.1	(20)	Not Encountered	Not Encountered
FS00—3	23 Aug 2000	6.1	(20)	Not Encountered	Not Encountered
FS00—4	23 Aug 2000	6.1	(20)	Not Encountered	Not Encountered
FS00—5	23 Aug 2000	6.1	(20)	Not Encountered	Not Encountered

3.2. Standard Penetration Tests

Standard penetration tests were taken in all borings at depth intervals of 76cm (2.5 feet) for the first 3 meters (10 feet) and every 1.5 meters (5 feet) for the remaining depth of the boring. The standard penetration obtained in accordance with ASTM D 1586-84 “Penetration Test and Split-Barrel Sampling of Soils’, using a 63.5kg (140-pound) automatic trip hammer.

3.3. Disturbed Sampling

Representative disturbed samples of the subsoils were taken with a 50.8mm (2.0— inch) O.D. standard steel split spoon sampler using a 63.5kg (140-pound) automatic SPT hammer, in accordance with ASTM D 1586—84. Samples were collected every 76cm (2.5 feet) for the first 3 meters (10 feet), then every 1.5 meters (5 feet) for the remaining depth of the hole. Samples were placed in a 0.47-liter (1-pint) jar and the lid sealed airtight with at least three wraps of electrical tape. Each jar was labeled, denoting the hole number, sample number, depth of sample, date collected, and the project name. The jars were placed in wooden boxes that were subsequently labeled with the appropriate project information.

3.4. Undisturbed Sampling

Undisturbed samples were attempted using 76.2 mm (3-inch) O.D. Shelby tubes, however due to the granular nature of soils at the target depths, sample recovery and quality was unsatisfactory for testing.

4. Laboratory Testing

Tests were performed to determine visual classification, Atterberg Limits, grain size distribution, natural moisture content, sulfate ion content, soil pH and soil resistivity. All tests were conducted in accordance with EM 1110-2-1906 "Laboratory Soils Testing".

Based upon the results of the testing program, the field logs were revised and supplemented as shown on the boring logs. These final logs represent an interpretation and compilation of the content of the field logs and the results of the laboratory tests of the field samples. The stratification lines shown on the boring logs represent the approximate boundaries between soil types; these transitions may be gradual.

5. Site Conditions

5.1. General Geology

Denver is located in the Colorado Piedmont Section of the Great Plains Physiographic Province. This section consists of late mature-to-old elevated alluvial plain. An original mantle of Pleistocene sand and gravel has been progressively removed by stream erosion so the area consists of mesas topped by sand and gravel, bordered by stream valleys. Overburden generally consists of sands, gravels and clays of alluvial origin. Bedrock is commonly the Laramie or Fox Hills Formation(s) of Cretaceous age. Due to the relatively shallow boring depths attempted during this investigation, it is not known how thick the overburden actually is.

5.2. Site-Specific Geology

Surface soils encountered at this site are typical of those found at the installation, comprised mainly of sandy clay and lean clay. Silty sand and sand with silt or clay was found in the middle to lower portions of the borings. The boreholes caved within these granular materials, an indication of low cohesion. The soils encountered should be suitable for use as fill and structural fill; however, as is often seen at Denver the near-surface layers are in a somewhat low density state as evidenced by Standard Penetration Test results.

5.3. Ground Water

Ground water was not encountered within 6.1 meters (20 feet) of the surface during the subsurface investigation. Except for isolated areas of perched water, ground water is not typically found within normal excavation depth at the installation, nor is it anticipated at this site.

5.4. Seismic Evaluation

The state of Colorado has a low to moderate frequency of earthquakes in historic time. In reference to NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Structures (1997), and USACE TI 809-04 Seismic Design for Buildings, (Dec 1998), this site has a short period (0.2-sec) spectral acceleration, Ss, of 0.17g, and a one—second spectral acceleration, S_1, of 0.057g. In accordance with the criteria, the location has a Site Classification of "D".

6. Subsurface Recommendations

6.1. General

Soils at the project site consist primarily of lean clay, lean clay with sand, and sandy lean clay (CL), with silty sand (SM) and sand with silt (SW-SM, SP- SM) below. High plasticity clay (CH) was not encountered at the site, nor is it anticipated. If high plasticity clay is encountered during excavation, it should not be subsequently used for fill or backfill material. Prior to adding fill to the site, topsoil should be stripped and the subgrade soils scarified and recompacted. A slope of at least 1 percent and preferably 5 percent should be maintained within 3 meters (10 feet) of structures to ensure adequate drainage.

6.2. Foundation Recommendations

6.2.1. Shallow Spread and Continuous Footings

The recommended foundation type for this design is shallow spread and continuous footings bearing on a layer of recompacted native soil. Footings should be designed for an allowable excess bearing capacity of 120 kPa *(*2500 psf). This value represents the maximum allowable bearing pressure at the base of the footings in excess of that due to existing surrounding overburden.

Footings should bear on lm (3.3 feet) of native soil that has been removed and recompacted in 200mm (8-inch) lifts to a density of not less than 95% of maximum Modified density. The over excavation and filling should extend a minimum of l m *(3.3* feet) beyond the outside edge of the footing.

All exterior footings for heated structures should be founded a minimum of 91cm (3.0 feet) below final exterior grade to provide adequate frost protection.

All footings for unheated structures should be founded a minimum of 91 cm (3.0 feet) below final exterior grade to provide adequate frost protection.

6.2. Slabs on Grade

A vapor barrier overlying a l50 mm (6-inch) capillary water harrier will be required beneath all floor slabs on grade. A modulus of subgrade reaction "K" of 5.56 kg/cc (200 pci) is recommended for this case (without frost penetration). Slabs on grade may be placed directly on the existing subgrade provided it is not disturbed during construction activities. Disturbed areas should be scarified to a depth of 200mm (8 inches) and compacted to 95% of maximum Modified density.

6.3. Pavement Design

Soils underlying pavement are predominantly lean clay and sandy lean clay (CL). These soils have a frost design classification of F3.

If rigid pavement design does not consider frost penetration, a modulus of subgrade reaction "K" of 4.87 kg/cc (175 pci) is recommended for design purposes. Flexible pavement designs should use a California Bearing Ratio (CBR) value of 8 for subgrades compacted to 95 percent of maximum density per ASTM D 1557-78 when frost is not allowed to penetrate the subgrade. If frost penetration is considered in the design of rigid or flexible pavements, the design shall be in accordance with TM 5-818-2" Pavement Design for Seasonal Frost Conditions".

6.4. Settlement

Based on Standard Penetration Test results and experience with engineered fills on previous projects, total settlement should not exceed 25mm (1.0-inch) under the recommended loading conditions if the removal and recompaction of soil below footings as described is performed. Differential settlement should not exceed 19mm (0.75-inch) under such conditions.

6.5. Cementing Properties

Sulfate ion content tests were performed on representative samples from footing level of borings FS00-2 and FS00-4.

Test results indicated the sulfate ion content at less than 0.1 percent. Based on criteria outlined in ACI 201.2, a mild exposure condition exists and sulfate-resistant cement will not be required for concrete in contact with soil or groundwater.

Due to the potential for alkali—aggregate reactivity, cement meeting the optional chemical requirements for low alkali cement on Table 2, ASTM C 150 will also he specified for all concrete. The Resource Conservation Recovery Act (RCRA) mandates, where possible, all concrete specifications will also include the option to use pozzolan as a partial replacement for portland cement.

6.6. Corrosion potential

Soil resistivity Tests were performed on representative samples from borings FS00-2 and F500-4. Test results indicated a resistivity of 2950 ohm-cm and 3130 ohm-cm, respectively. In accordance with corrosion classifications in the Department of the Army TM 5-811-4 (17 March 1965), "Electrical Design, Corrosion Control", a "moderate" corrosion potential is expected. Soil pH measured 7.9 and 8.3 respectively.

7. Construction Considerations

Relatively few construction-related problems are found at Denver, CO. Historically the most common is an inability to achieve compaction in some of the granular soils. Since most of the granular soils at this site are located below the over excavation depth, this should not present a difficulty.